PAN-PACIFIC ENTOMOLOGIST
62(2), 1986, pp. 111–118

New Record and First Observations of Adult Flight Activity for *Deuterophlebia coloradensis* Pennak (Diptera: Deuterophlebiidae) in Idaho[1]

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Abstract.—Adults and immature stages of the mountain midge *Deuterophlebia coloradensis* Pennak were collected from a small river in northern Idaho, and represent the first records for this family from the state. The adult emergence of this species was observed over two-week periods in 1984 and 1985. Flight activity lasted for 25–45 min beginning about 8:30 AM PST. Differences were noted in sex ratios of netted adults between 1984 and 1985, with females outnumbering males in the latter portion of the first year and males outnumbering females in the second. However, the pupal sex ratio monitored during the adult emergence indicated that the overall sex ratio was near 1:1. Observations of the adult emergence and flight activity are the first reported for this species.

The present distribution of *Deuterophlebia coloradensis* Pennak extends throughout the Rocky Mountain system as first suggested by Pennak (1951), and now includes Colorado, Wyoming, Utah, Alberta and perhaps Oregon. This paper is the first record of this species from Idaho.

We undertook this study in order to learn more about the biology and adult habits of this poorly known midge. All life stages for the species involved in this study were collected. The species was identified initially as *D. coloradensis* primarily from pupae gathered at the study site and keyed in Kennedy (1960). Adult males collected subsequently compared well with features used by Kennedy (1958) to distinguish this species. Identity of adults and immatures was confirmed by G. Courtney, University of Alberta, Edmonton.

MATERIALS AND METHODS

We used several methods to sample the different life stages. Larvae and pupae were found by searching surfaces of submerged rocks. Drift nets trapped adults rising from the substrate and those dropping into the water. Empty pupal skins or those with partially-emerged adults also occurred in these drift samples. Most adults were captured on the wing using 30 cm aerial nets; additional imagos were found in spider webs, on riparian vegetation, and on ephemeral rain puddles in nearby roadways.

[1] Scientific Paper No. 7289, Agricultural Research Center, College of Agriculture and Home Economics, Washington State University, Pullman, Washington. Work was conducted under Project 9043.

All field studies on *D. coloradensis* were conducted during May, June and July in 1984, and May and June in 1985, along a stretch of the Potlatch River, ca. 5 km S Helmer (Latah County), Idaho (Fig. 1). This area can be characterized as mixed conifer forest with Douglas fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and grand fir (*Abies grandis*) as dominant trees. Snowberry (*Symphoricarpos albus*), serviceberry (*Amelanchier alnifolia*), wild rose (*Rosa* sp.) and willows (*Salix* spp.) are the primary understory plants. Additional visits to the study site were made on July 13 and November 1, 1984, and March 10, 1985, but no midges in any stage of development were found. During late summer and fall the stream flow is greatly reduced exposing many large rocks. At this time submerged rocks are typically covered by a thick coating of algae and trapped sediments.

Observations were made at several riffle areas located ca. 0.8 km upstream and downstream of the Little Boulder Campground. Elevation at the study site was 800–815 m. At this point the river is 10–15 m wide, 30–60 cm deep and flows along a shallow gradient at a velocity of 0.65 to 1.1 m/sec. The substrate was primarily small boulder and cobble of black basalt with some quartz and granite. Areas of gravel, mud and sand bars are common, especially along the banks. Additional riffle areas occur both above and below the primary study sites.

River conditions vary considerably from spring to summer. In early May of 1984, when most larvae were found, the river was cooler and ran higher due to snow melt further upstream. Water covered all rocks except those at the margins. By June the water level had dropped so that many of the larger rocks were partially exposed or remained covered by only a few cm of water, unless rains swelled the river to near May levels. We estimated that the river conditions in 1985 were advanced 3 weeks for the same interval in 1984. This accelerated season was due to a smaller snowpack and unseasonably warm, dry spring weather.

Sex ratios were analyzed using a Chi-square test. Ratios given in the following text should read males : females.

Results

1984

Larvae of *D. coloradensis* were first discovered on May 5. All larvae were closely associated with upper and lateral surfaces of submerged rocks which were without apparent algal growth and in water 30–50 cm deep. The larvae were found only in riffles at midstream; none were on rocks in slower water near the river margins. About 30 larvae of various sizes and 2 male pupae were collected. No additional pupae could be located.

Other immature aquatic insects found in this same riffle habitat included: *Leucotrichia* and *Ochrotrichia* spp. (Trichoptera: Hydroptilidae), *Agathon elegantulus* von Roder (Diptera: Blephariceridae), *Maruina* sp. (Diptera: Psychodidae), *Antocha* sp. (Diptera: Tipulidae), and *Parargyractis* sp. (Lepidoptera: Pyralidae).

On June 3, additional *D. coloradensis* immatures were collected. Later larval instars and pupae replaced many of the smaller larvae seen earlier. The pupae were tucked into small, shallow depressions and cracks on the upper and lateral surfaces of the rocks. From the sample of pupae collected, the sex ratio (19:16) was not significantly different from 1:1 ($P > 0.5$). Several pupal cases were empty but otherwise intact suggesting that adults had recently emerged. All larvae and

Figure 1. Typical riffle area habitat of *Deuterophlebia coloradensis* on the Potlatch River during May 1985.

pupae were located beneath the water line and none were found on exposed surfaces or within the splash zone.

Flights of adult *D. coloradensis* were first observed on the morning of June 11. Additional adults were seen on subsequent visits to the study area on June 13, 15 and 24. No larvae or adults and only one fragmented pupal case were found on July 13. Adult flight was limited to ca. 30 min periods between 8:30–9:00 AM PST on each of the mornings except the last (June 24) when adults were present from 8:05–8:30 AM PST.

The adults, although small, were recognizable by the characteristic blue gray color of their wings when contrasted against the background of the darkened opposite shore and early morning shadows. The color is accentuated further by sunlight reflected from the wings as the midges moved from shaded areas into full sunlight. This reflective property of the wings made identification at a distance possible, even when the adults moved among other flying insects (e.g., chironomids and hydroptilid caddisflies).

Individual adults seemed to emerge directly from the water and fly upward at a steep angle with little or no pause at the surface. None were observed clinging to rocks before or during the emergence period. Once airborne, their movement was primarily upstream and along the water course at midstream. Few adults flew over the stream margins and fewer still along the adjacent bank. Individual flight was erratic, although adults were readily netted when the collector stood at midstream. Once within the net, the midges either clung to the side in the position described by Kennedy (1958), or pushed off and fluttered about the confined space.

Flight of the delicate adults was dictated by almost any perceptible air movement. On June 11, flight was especially heavy with hundreds of individuals on the wing at once. The regular upstream flight pattern was periodically interrupted by a shifting breeze up to ca. 5 km/hr which concentrated and propelled the midges before it, either upstream or downstream. In lulls between gusts, some upstream movement continued, but the midges would appear again in numbers as wind velocity increased. Many individuals were easily captured by holding the net into the wind.

Equitability in the sex ratio was found for the total specimens taken on June 11 (25:23) and 13 (8:6) ($P > 0.75$), but the ratio shifted and females increasingly outnumbered males on subsequent days (June 15 and 24) to 9:24 and 1:24 ($P > 0.05$), respectively. On the first morning air movement wafted most midges into our nets held at all levels from the water surface up to 3 m. On the last 3 days wind velocities were reduced and flight of the midges was straight or slightly coursing but at eye level (ca. 2 m) and not much above. None were seen to dip down and touch or land on the water surface. Attempts to identify and collect males from these flights, especially on the latter 2 days (June 15 and 24), were singularly unsuccessful and only females were netted.

Following each flight period, dead and dying adults were sought on objects or vegetation in the area immediately adjacent to the river. Fourteen intact midges were picked from spider webs on June 10, the day before the flight of adults was first observed. Three males were in webs attached to vegetation just above (ca. 15 cm) the water's edge and 11 (10 males, 1 female) in webs higher (ca. 1.5 m) on shrubs overhanging the river. One additional female was swept from a grassy bank flanking the riffle area. On June 11, 8 males were recovered from the surface of small rain puddles in a dirt roadway that paralleled the river. All puddles were separated from the river by a moderately high (2.5–3 m) barrier of shrubs including *Salix, Amelanchier,* and *Symphoricarpos.*

Potential predators of *Deuterophlebia,* besides spiders, included predaceous flies, especially species of dance flies (Diptera: Empididae). Several species of dance flies were active during the time the deuterophlebiids were in flight. Two small species each of *Hilara* and *Rhamphomyia* (*R.* [*Megacyttarus*] *anthracodes* Coquillett and *R.* [*M.*] sp. nr. *scaurissima*) were observed skimming the water surface apparently hunting prey. *R.* (*M.*) *disparilis* (Coquillett), a larger species, was seen swarming at a height of 2.5 m above the water. Although none of the empidids was carrying prey when netted, all can be considered possible predators of emerging deuterophlebiids, especially the smaller empidid species active at the surface. Predation on newly emerged black flies (Simuliidae) and mosquitoes (Culicidae) by empidids has been reported by several workers (Frohne, 1952; Hubert, 1953; Peterson and Davies, 1960).

1985

In 1985, the study area was first visited on March 10; no larvae or pupae were found. It was on May 18 when the first larvae (174) and pupae (124) were collected. The larvae showed a high degree of variability in size. The pupae ranged from newly pupated forms to mature and tanned individuals. No empty puparia were found on this date indicating that emergence had not yet begun. The number of

male to female pupae was 50 to 74, respectively, which was significantly different from a 1:1 ratio ($P \leq 0.05$). Spider webs near the river were checked for adults and none were found. Water conditions and location of larvae on the substrate during adult emergence were similar to those of 1984, although 3 weeks earlier.

On May 24, an emergence of adults was observed with flight activity commencing at ca. 8:30 AM PST and lasting for ca. 45 min. Adults were observed flying immediately above the water surface and rarely exceeding 15 cm in height. Unlike the previous year, they were more difficult to see when viewed from above against the stream surface and extremely difficult to capture with insect nets. The distribution of adults appeared to be clumped rather than random. Groups of adults moved swiftly above riffle areas and remained together as cohesive units. Estimates of the group size ranged in number from 6 to over 50 individuals. No pairing was observed within these groups. Only once, due to a gust of wind, were adults sighted anywhere but directly above the surface of the riffle area of the river. Immediately following this event, midges were again seen directly above the water surface. During the first 15 min of flight, the sex ratio of adults collected was approximately 7:1 ($n = 105$), and for the remainder of the flight period (8:45–9:15), the sex ratio was 15:1 ($n = 158$). The overall sex ratio for the flight period was 10:1 ($n = 302$). Adults were found in spider webs in close proximity to the water. Only one adult was seen in a spider web more than 1 m above the water. Of the 433 specimens collected from spider webs nearer the water than 1 m, 418 were males indicating a 28:1 sex ratio. Spiders constructing these webs were determined to be *Tetragnatha* (Araneae: Tetragnathidae). However, these spiders were not observed feeding on the midges.

Ten stones were sampled on May 24 from one riffle area where the majority of the adults were netted during the flight period. Rocks were removed from the water and all observable immature stages of *D. coloradensis* collected. We found fewer male than female pupae (67:86). However, the difference was not significant ($P > 0.1$). Pupal exuviae were also collected from these rocks. The male : female ratio (9:16) did not differ significantly from 1:1 ratio ($P > 0.1$). Pupae were more abundant than larvae, 153 to 32.

Drift samples were taken above and below riffle observation areas. The drift sample from above the riffle was positioned near the end of a slow-moving section of the river. From both drift samples, adults, empty puparia and adults partially eclosed from puparia were collected. The samples taken just downstream of the riffle area generally trapped more deuterophlebiid midges than the samples from above the riffle. The sex ratio of puparia collected was 38:40 which was not significantly different from 1:1 ($P > 0.75$). Few eclosed adult midges were collected in these samples. Three live adult females, 2 of which had lost both wings, were found in a drift net sample just after the flight period.

On June 11 another emergence of deuterophlebiid midges was recorded. The flight period began approximately at 8:30 AM and lasted for 45 minutes. Considerably fewer adults were flying as compared to May 24. The sex ratio of netted adults was 10.5:1 ($n = 92$) which was significantly different ($P < 0.05$). Flight activity on this date was similar to that observed on May 24 with adults typically moving about in groups just above the water surface. Again, no pairings were seen in these groups. Following the emergence, spider webs near the water were inspected for midges, but few were found.

Discussion

Kennedy (1981) reported that larvae of mountain midges were collected from light colored rocks. We discovered that larvae could also be collected from black basalt boulders, the predominant component of the substrate of the Potlatch River. Further, the larvae apparently showed no preference for light colored rocks over dark ones. The small, essentially transparent larvae were almost invisible on dark rocks but were more easily detected on light ones. We were able to see larvae on black basalt by first removing these dark rocks to the shore and allowing them to dry. The larvae were more apparent when their outline became defined on the drying rock. This observation and collecting method may provide additional distribution records when other stream systems with essentially black substrates are checked.

The collections made of adult *D. inyoensis* Kennedy (Kennedy, 1960), *D. nielsoni* Kennedy (Kennedy, 1958), and *D. coloradensis* (Pennak, 1950) have indicated adult sex ratios greatly favoring males even though pupal sex ratios of approximately 1:1 have been found for those same populations. Conclusions by Pennak (1950) were made from collections of adults taken from the surface of calm backwaters of a mountain stream sometime after the flight period. Our 1985 collection of netted adults and adults collected from spider webs also indicates a skewed sex ratio favoring males (15:1, $n = 827$). The overall sex ratio of pupae was not significantly different from 1:1 ($n = 277$, $P > 0.05$). The observations of 1984 differed greatly from those of 1985. Kennedy (1958) reported the adults to be rapid fliers that spend most of their time flying near the surface as we observed in 1985. In 1984 our observations were made under breezier conditions as compared to those in 1985. On May 24, 1985, a gust of wind caused the midges to rise from immediately above the water surface to a height of ca. 1.5 m above the water. This incident approximated the conditions under which most observations were made in 1984. We believe that air movement was responsible, at least in part, for the differences in observed flight behavior between years. In 1984 we focused our observations on flies at 1.5 m and may have overlooked swarm activity at the surface.

Under normal conditions, as occurred in 1985, it is hypothesized that females are mated soon after taking flight and encountering a group of males. It is not known if the pair *in copula* remains in the swarm. Once mated, the females probably leave the swarm area above the water and begin to oviposit. However, we do not know where oviposition occurs. The males may then return to a swarm to continue looking for and mating with other females. This scenario may explain the observed discrepancy between adult and pupal sex ratios. On May 24 collections of adults from the first half of the emergence period showed a greater number of females than in the second half by a 2 to 1 margin. This trend may indicate a decrease in the number of females in the swarm due to successful matings after which the females leave the swarm. At this point it is impossible to tell whether males were joining the swarms and increasing the male : female sex ratio. If the latter were true the swarm size should have doubled, but no increase of this magnitude was observed. When conditions were breezy, as in 1984, it is possible that low level swarms were blown upward from the water surface and females were not intercepted and mated, hence their increased presence in our samples.

However, this hypothesis cannot explain the increased number of females above a 1:1 ratio which was the case in 1984 when a 1:1.8 male : female ratio was observed. Kennedy (1958) also reported netting males with eggs and sperm adhering to their bodies, which implies that aerial mating occurs and that males probably continue to swarm following mating. No pairing or mating pairs were observed during any periods of observations.

Drift net samples on May 24, 1985, collected a number of empty puparia. These puparia were assumed to be from that morning's emergence since several contained fresh, partially-emerged adults. These data also seem to indicate that even though a collection of adults yielded a male skewed sex ratio, the total numbers of males and females that emerged that day were approximately identical.

Summary

This work represents the first report of *D. coloradensis* in Idaho and records observations of its adult flight activities. In Idaho, this species apparently produces one generation yearly resulting in a single, daily adult emergence which extends seasonally over at least 2 weeks in May and/or June, depending upon conditions.

The immatures can be found on both light- and dark-colored stream rocks. However, transparent larvae are more evident when dark rocks were allowed to dry slightly.

The midge exhibits strictly matinal flight activity with periods of swarming lasting from 25–45 min. Imagos course just above the water surface, typically in riffle areas, unless wind movement forces them upward to heights of 1–3 m. Besides our observations, evidence of higher flight was confirmed by the discovery of dead, adult males on the surface of puddles well separated from the river by high (2–3 m) vegetation and in spider webs positioned at ca. 1 m above the water. Mating and oviposition were not observed.

Under normal conditions, the sex ratio of netted adults shifts from equal numbers early in the flight period toward predominantly males later. Females probably leave the swarm in order to oviposit after mating, unless conditions disrupt the normal mating activity. Their departure would significantly reduce the number of females, as we observed. The sex ratio of pupae collected during most sampling periods was equal. Our conclusion is that the pupal cases, especially empty ones, are good indicators of the true sex ratio for *D. coloradensis*.

Acknowledgments

We especially appreciate the assistance of Gregory Courtney, Department of Entomology, University of Alberta, Edmonton, who confirmed the identity of the midge and reviewed the initial manuscript. Other identifications were provided by Charles L. Hogue, Los Angeles County Museum (Blephariceridae) and Donald Denning (Hydroptilidae). The manuscript was also critically reviewed by James B. Johnson, University of Idaho, Moscow, and Norman E. Woodley, Systematic Entomology Laboratory, USDA, U.S. National Museum, Washington, D.C.

Literature Cited

Frohne, W. C. 1952. Water level predator of emerging mosquitoes. Mosq. News, 12:263.

Hubert, A. A. 1953. Another species of *Rhamphomyia* predaceous on mosquitoes (Diptera: Empididae). Pan-Pac. Entomol., 29:190.

Kennedy, H. D. 1958. Biology and life history of a new species of mountain midge *Deuterophlebia nielsoni,* from eastern California (Diptera: Deuterophlebiidae). Trans. Am. Microsc. Soc., 77: 201–228.

———. 1960. *Deuterophlebia inyoensis,* a new species of mountain midge from the alpine zone of the Sierra Nevada range, California (Diptera: Deuterophlebiidae). Trans. Am. Microsc. Soc., 79:191–210.

———. 1981. Deuterophlebiidae. Pp. 199–202 *in* J. F. McAlpine et al. (eds.), Manual of Nearctic Diptera, Vol. 1. Agric. Canada, Monogr. No. 27, 674 pp.

Pennak, R. W. 1950. First record of adult mountain midges from North America (Diptera: Deuterophlebiidae). Entomol. News, 61:36.

———. 1951. Description of the imago of the mountain midge *Deuterophlebia coloradensis* Pennak. Amer. Mus. Novitates, No. 1534, pp. 1–11.

Peterson, B. V., and D. M. Davies. 1960. Observations on some insect predators of black flies (Diptera: Simuliidae) of Algonquin Park, Ontario. Can. J. Zool., 38:9–18.

Publications Received and Briefly Reviewed

Systematics and Biogeography of the Longicorn Beetle Tribe Tmesisternini. By J. Linsley Gressitt. Pacific Insects Monograph, No. 41, iv + 263 pp., 20 figs., 12 pls. (4 colored). Publication date given on review card as 30 December 1984. Received by PCES at CAS on 20 February 1985. Published and distributed by Bishop Museum Press, P.O. Box 19000-A, Honolulu, Hawaii 96817, USA. Price $23.50 paperbound. ISSN 0078-7515.

The abstract states:

> The range of the cerambycid (lamiine) tribe Tmesisternini essentially covers the area known as Melanesia plus Wallacea (in the original sense—Sulawesi, Lesser Sunda Is), as well as Maluku, the south fringe of the Sunda Is and the NE fringe of Australia. The group has not yet been recorded from Vanuatu (New Hebrides) or Fiji, though it is known from New Caledonia. The tribe comprises 15 genera and 422 species, of which 1 genus and 99 species are described as new in this paper. The majority of the species occur in New Guinea, with distribution now known as follows: New Guinea mainland, 291 species; New Guinea offshore islands, 42; Aru, 19; Kei, 6; Maluku, 35; Sulawesi, 9; Sunda Is, 2; Lesser Sunda Is, 14; Bismarcks, 20; Solomon Is, 12; New Caledonia, 11; Australia, 19. Relatives of this tribe are mostly concentrated in New Caledonia, Wallacea (broad sense including Philippines), SE Asia, Japan, Sri Lanka, Micronesia, Samoa, Fiji and New Zealand, with areas in between, including NE Australia. Several of the Tmesisternini have been recorded as borers of living cacao trees. Original host-plants probably include many rain forest tree species, but several bore in larger ferns, including bracken and tree-fern petioles.

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